Studies in Cyperaceae in southern Africa. 29: *Costularia natalensis*, an endangered species

J. Browning* and K.D. Gordon-Gray[1]

*NU Research Unit for Plant Growth and Development, [1]Department of Botany, University of Natal, Private Bag X01, Scottsville, 3209 Republic of South Africa

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Costularia natalensis is a poorly known subSaharan African endemic that should be regarded as endangered. Populations are restricted to highland massifs from Malawi southwards to South Africa (KwaZulu-Natal); small in extent, and widely scattered, they show no obvious evidence of regeneration. Generic relationships of the species are uncertain. A comprehensive description is given, supplemented by notes on morphological variability, fruit dispersal and ecological preferences, and distribution.

Keywords: *Costularia natalensis*, endangered, subSaharan Africa.

*To whom correspondence should be addressed.

Introduction

Costularia natalensis C.B. Clarke was established for plants from the former Transvaal and Natal (Clarke 1898: 274). It is a subSaharan endemic that has received little attention until recently, but is of interest primarily because its relationships are contentious and uncertain.

There is perhaps one other species of *Costulara* in Africa, namely *C. brevicaulis* (C.B. Clarke) C.B. Clarke (basionym *Tetraria brevicaulis* C.B. Clarke), which is a smaller plant with a somewhat different facies, and is localized and rare in the Western Cape Province. Both *C. natalensis* (Koyama 1961: 75; Gordon-Gray 1995: 190) and *C. brevicaulis* (C.B. Clarke 1894: 659; Levyns 1947: 82; Bruhl 1992 on disk) have a history of relationship with *Tetraria* P. Beauv., one or other having been incorporated into that genus by the workers named. The remainder of the distributional area of *Costularia* is more eastern. Clarke (1894: 658) listed several species from Madagascar and the Mascarene Islands. These relate to the African plants, especially *C. baroni* (Baker) C.B. Clarke, which was said to hardly differ from *C. natalensis*, except by the laxer panicle with slender flexuous branches. Plants from New Caledonia fall into two groups: one relates to the entities in Africa and Madagascar; the other has been treated as *Lophoschoenus* Stapf (Guillaumin 1938: 38; Hooper 1973: 864), or given subgeneric ranking under *Costularia* (Raynal 1974: 376). Two other species from Malaysia, *Costularia pilisepala* (Steud.) Kern and *Tetraria borneensis* Kern, are contentious in their generic placement (Kern 1974: 664–666).

It is clear that *Costularia natalensis* is of phylogenetic interest and requires further study. Recent articles have drawn some attention to the species. Burtt (1988: 78) stated that differences in the inflorescence between KwaZulu-Natal plants and those from Malawi should be investigated to test established taxonomy. He also remarked that as a species it 'has almost certainly suffered heavily from the planting up of grassland for timber', a comment that seems fully justified. Browning (1994: 653) proposed a new interpretation of floret positioning within the genus, based on specimens of *C. natalensis* from Zimbabwe. Browning & Gordon-Gray (1995 :70) found the African species of *Costularia* to be more closely affiliated to *Macrochaetium* Steud. than to *Tetraria*, on the basis of silica deposits in epidermal glume cells. In pursuance of this relationship, and in an endeavour to record the range of inflorescence and floral variability for the species in relation to Burtt's questioning of homogeneity within it, we studied some populations growing naturally, and herbarium exsiccatae representative of the entire known distributional range. In the context of the rarity and endangered status of the species, and because of the uncertainty of and therefore interest in its true relationships, this article presents the formal taxonomy of the species. This includes a comprehensive description based on South African specimens (previous descriptions are few and scant), and new information on floral variability, fruit structure and dispersal, with notes on habitat preferences and distribution.

Materials and Methods

Populations in the Vumba and Chimanimani Mountains of Zimbabwe were studied in February 1991 and May 1993 respectively. Before and after these dates, some KwaZulu-Natal and Northern Province localities were visited. Exsiccatae from the northernmost to southernmost distributional limits were available. A list of representative specimens studied is given under Formal taxonomy.

To count accurately the number of glumes per spikelet, it was essential to select spikelets in which the stamens of the lower floret were ready for anthesis (Figure 1). In older spikelets, glume abscission had already commenced naturally, or took place suddenly on dissection; younger ones were not sufficiently 'advanced' to permit complete dismemberment. Inflorescences from a range of localities were selected, and from each of these, 10 spikelets at the right stage of growth were investigated.

Micromorphological study of representative fruits was carried out. Some embryos were removed after other fruits had been soaked in water for 24 h. These were transferred to lactophenol for 5–10 h for clearing. Salient features could be observed but tissue density precluded good photographic images suitable for publication.

Formal taxonomy

Costularia natalensis *C.B. Clarke* in Conspectus florae africae 5: 658 (1894) name only; C.B. Clarke 7: 274 (1898) description; Schonland: 58 (1922); B.L. Burtt: 77 (1988).

Tetraria natalensis (C.B. Clarke) T. Koyama T. Koyama: 75 (1961); Gordon-Gray: 190 (1995). Syntypes: Natal, without stated locality but probably Noodsberg (see Burtt 1988), *Buchanan 152, 354* (K).

Perennial, herbaceous, tufted. *Rhizome* 1.0–1.5 mm in diameter, woody, erect, producing short lateral branches that become semi-erect closely adjacent to the main rhizome, thereby increasing tuft size, clothed in thick adventitious roots followed by coarse, persistent leaf bases up to 15 mm wide. *Culms* erect, 0.6–

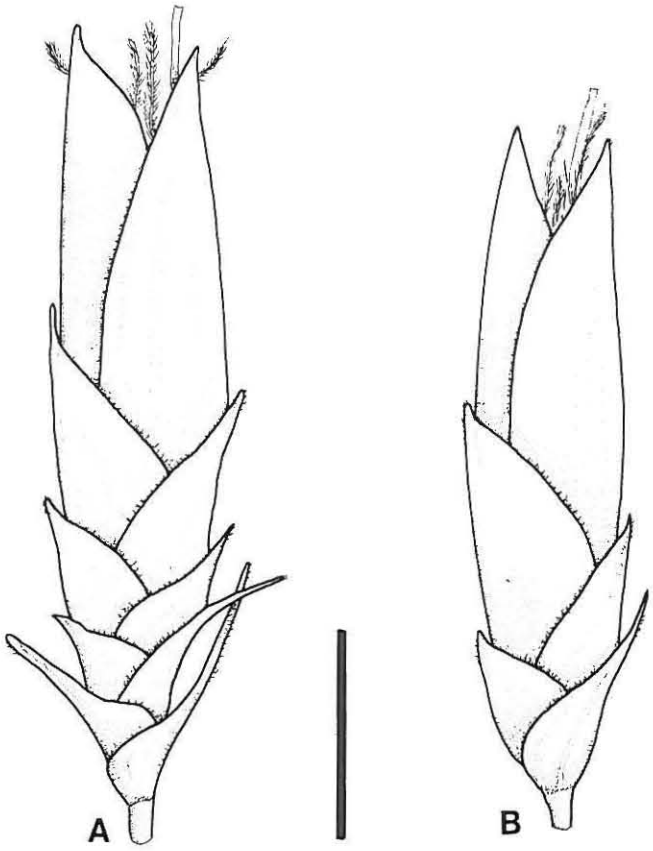

Figure 1 *Costularia natalensis*: spikelets. A, from Zimbabwe, Chimanimani, *Browning 579* (NU); B, from South Africa, *Hilliard & Burtt 15468* (NU). Scale bar = 2 mm.

1.8 m in total length, clothed basally in persistent, brittle, dead, spirodistichously arranged leaf bases (often forming a collar) that grade into living radical foliage leaves, nodose, nodes dark chestnut brown to blackish-red, occasionally light brown, proximal 2–4 sterile, distal 4–12 each bearing 1–3 floral branches; internodes subtrigonous, slightly flattened or terete, hard, glabrous, glaucous-green. *Leaves* radical and cauline, numerous; radical with sheaths poorly defined, short in relation to blade length, closed in young leaves, soon splitting and flattening, eligulate, blades 0.3–0.6 m long, gradually tapering from base where (3–)6–10 mm wide to (1.5–2)3–4 mm at midlength, to elongate, curling apices ± 1 mm wide, tough, glabrous, margins scabrous; cauline with sheaths closed, enveloping up to half of internode length, mostly green except for narrow brown membranous margin to long narrow V-shaped mouth, eligulate; blades as for foliage leaves but reduced in size, giving place to still smaller bracts at reproductive nodes. *Inflorescence* a panicle, ± continuous, of closely packed, erect spikelets grouped in ± elongated, irregular clusters borne on 1–3 axillary branches from each of 4–8(–12) distal culm nodes, or appearing interrupted with ± nodding clusters if branches and ultimate branchlets are long and droop with weight of maturing spikelets and rainwater (robust plants). *Bract* 1 from each node, reduced in size upwards so that most distal bract apices only shortly surpass spikelet clusters. *Spikelets* solitary, occasionally ± paired, pedicelled or subsessile, oblong in outline, 6–9 × 1.8–2.0 mm, dull dark brown, soon disintegrating above lowest pair of glumes. *Glumes* subdistichous, 6–12 in total number, proximal 3–9 empty, of which lowest 1–3 frequently with apex attenuate, remainder increasing in length upwards, apices acuminate or acute, next 3 largest, 6–7 × 3 mm, boat-shaped, glabrous except for well-marked ciliate margin, apex obtuse, toothed, but rolled so appearing narrow, and almost acute until unfolded, uppermost glume enclosed within the two preceding, slightly shorter, prophyll-like with two ridges suggestive of veins, presumably due to pressure of developing florets, abaxial surface distally shortly pubescent especially on ridges, margin ciliate, apex toothed. *Florets* 2 only, lower functionally male, usually with rudimentary gynoecium, upper bisexual. (No variation in this positioning was found.) *Glumellae* 3 + 3, delicate but strong, 6–7 mm long, white, villous in distal half, bases with prickle hairs (Figure 3D). Stamens 3, within (above) and alternating with inner rank of glumellae, filaments persistent 5–7 mm long after anthesis, ribbon-like; anthers linear-oblong, large, apiculate, early deciduous. *Style base* in life globose, with faintly marked longitudinal angles, soft, shining white, pubescent to villous apically, collapsing as achene matures to form a series of irregular flaps or bulges and darkening in colour, style ± length of glumellae, dark brown, style branches 3, coarsely plumose, proximal portion of style persistent as short to long beak on fruit (Figures 3A, B, C). *Achene* globose, narrowed basally into funnel-shaped extension ± ¼ length of globose portion, 5.0 × 3.0 mm in total length and width, faintly 3-ridged longitudinally, whitish to pale fawn; surface smooth to slightly transversely rugose.

Morphological variability

Inflorescence

Burtt (1988: 78) contrasted the 'graceful inflorescence with very dark, pendulous spikelets' of the Mulanje plants with the 'stiffer, with erect brown spikelets' of inflorescences produced by plants in the former Natal and Transvaal. Our observations indicate that these differences depend mainly upon the following variables:

(1) length of the axillary branches that carry spikelet clusters;
(2) degree of division and length of the branchlets within these clusters; particularly the ultimate divisions that carry the usually solitary, or occasionally paired, spikelets;
(3) the stage of development of the inflorescence.

Examination of a range of specimens has revealed that, while the distinctions noted by Burtt make extremes appear different, the criteria upon which the differences depend are of degree and vary individually among plants, so that intermediate states and stages exist. We found no clear discontinuities to suggest that features of the inflorescence may provide a basis for subdivision of the species.

Spikelet structure

The accepted interpretation of spikelet structure was of subdistichous glumes, the proximal four or more, empty, followed by three distal larger ones that subtended respectively, a male floret and a bisexual one, with the uppermost, which is totally enveloped by the two preceding larger ones, empty (Chermezon 1936/1937; Raynal 1974; Goetghebeur 1986; Bruhl 1992). A recent study has revealed that the uppermost glume actually envelopes the bisexual floret during much of the floret's development. As the ovary matures, it enlarges beyond the limits of this glume, which then appears empty (Browning 1994: 655). The lower of the two largest glumes is sterile. No variation from this modified interpretation was encountered during the present study.

Glume number

The total number of glumes per spikelet is variable. There is little constancy within an inflorescence, from one inflorescence to another on the same and on different plants, and from one locality to another. Variability in total spikelet number results from differences in the number of smaller proximal glumes developed below the two largest 'paired' glumes that appear to terminate the spikelet, but which in reality enclose the thinner, shorter

Table 1 *Costularia natalensis* in subSaharan Africa. Variability in total glume number. Ten spikelets taken as samples from each of 21 inflorescences from plants growing in 14 localities

		10 spikelets per inflorescence: total number of glumes per spikelet						
Grid ref:	Locality	6	7	8	9	10	11	12
1635 BB	Malawi – Mulange 1		7	3				
	Malawi – Mulange 2		4	6				
	Malawi – Mulange 3		5	5				
	Malawi – Mulange 4		7	3				
	Malawi – Mulange 5		1	6	3			
1932 BA	Zimbabwe – Castle B. 1			4	5	1		
1932 BA	Zimbabwe – Castle B. 2				5	5		
1933 CC	Chimanimani 1			1	4	4	1	
	Chimanimani 2					2	4	4
2330 CC	S. Africa – Wolkberg		5	5				
2430 DD	S. Africa – Graskop		1	4	4	1		
2530 BB	S. Africa – Witklip		8	2				
2631 AC	Swaziland – Dalriach		5	4	1			
2631 CA	Swaziland – Usutu For. 1		7	1	2			
	Swaziland – Usutu For. 2	1	8	1				
2731 CD	S. Africa – Ngome	1	5	4				
2830 DB	S. Africa – Qudeni	1	7	2				
2930 AC	S. Africa – Karkloof	1	8	1				
2930 BD	S. Africa – Noodsberg		6	4				
2930 DA	S. Africa – Inchanga		10					
3030 AD	S. Africa – Umzinto	3	5	2				
Grand total of 210		7	99	58	24	13	5	4
Percentages of total nos sampled		3.3	47.1	27.6	11.4	6.2	2.4	1.9

uppermost one (Figure 1). Our sampling of plants from 14 localities from Malawi to KwaZulu-Natal (Table 1) indicated that:

(1) the range in number of glumes per spikelet could vary from one population to another (compare extremes, namely Chimanimani 2 and Umzinto);

(2) when the range was the same, the proportions of spikelets with different glume numbers generally differed from one population to another (compare South Africa – Wolkberg, Witklip);

(3) the most commonly occurring glume numbers were 7 and 8 (see percentages derived from total numbers of spikelets sampled).

(4) the variability was not correlated with latitude.

Fruit and style base

Figure 3A–C is representative of the range in fruit and style-base structure encountered. The three longitudinal ridges to the fruit are clearly (Figure 3A), or faintly (Figure 3B, C), evident. The line that marks the funnel-shaped base varies from just visible (Figure 3B) to clearly defined (Figure 3A, arrow).

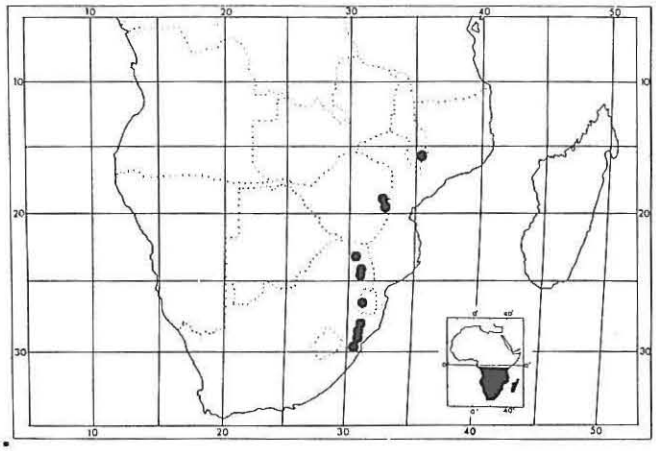

Figure 2 *Costularia natalensis*: recorded known distribution in Africa.

The style base is markedly variable. In life, during the middle to later stages of growth of the gynoecium, it is white, relatively soft and globose with several faint to more prominent longitudinal ridges, and shortly villous distally. With maturation and drying of the fruit, the style base shrinks, collapses and darkens to form lobes or bulges of tissue below the hairy distal portion (Figure 3A). Our observations record that if no embryo is developed, the pericarp shrivels while the style base remains expanded and chalk-white. Frequently, in plants from Malawi and Zimbabwe, less often in KwaZulu-Natal, the style base (and lower part of the style?) was elongated, hardened and flattened (compare Figure 3A with 3B, C). These linear structures were occasionally dark in colour when they broke easily to reveal black, granular material within; now and then the whole style base broke away and disintegrated. We speculate that these peculiarities may be the outcome of parasitism, either fungal or insectivorous.

Fruit dispersal and embryography

The glumellae, for all their delicate appearance, become tenaciously enwrapped within the enfolded apices of the distal large glumes, and are very difficult to free during dissection of a spikelet. When glume abscission takes place, as happens acropetally, the mature fruits, already abscised from the spikelet axis, are held among the glumes by the glumellae and the persistent filaments. These glume aggregations are distributed by wind and gravity. On reaching a water surface, the glumes and glumellae form a flotation system, operating to permit some drift before the fruits break away and sink.

Vanhecke (1974: 379) gave details of embryo conformation but did not name its type. He found it always located in the funnel-shaped base that is below the globose, endosperm-filled main portion of the fruit. Goetghebeur (1986: 816; Figure 8.12.28 C, D) described it as differentiated from the *Carex* type. Our findings on embryo structure support those of the authors cited.

Ecological preferences, habitat and distribution

C. natalensis is limited to the eastern side of the African subcontinent (Figure 2). Roughly paralleling a part of the coastline, lies a chain of individually isolated highlands associated with the rifting and vulcanism of the landmass. It is along this chain of highlands, particularly on the uplifts of the continental basement rocks, such as, for example, the Wolkberg, Sabie and Graskop areas of the Mpumalanga Drakensberg, that *C. natalensis* is present. Mount Mulanje in Malawi is the northernmost known locality; Umzinto in KwaZulu-Natal the southernmost. Popula-

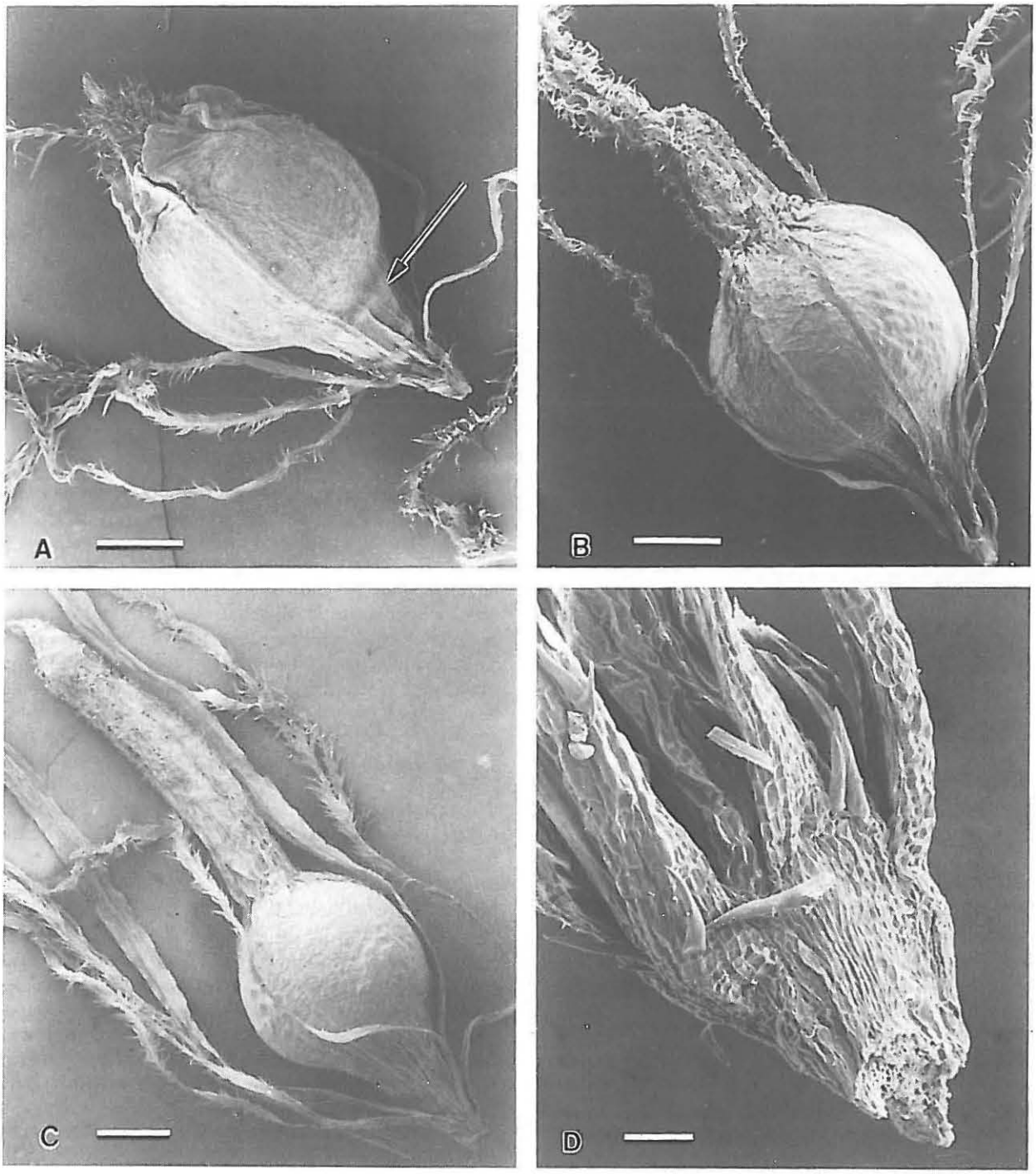

Figure 3 *Costularia natalensis*: achenes and style bases with glumellae attached. A, *Hilliard & Burtt 14532* (NU); B, *Fisher 1643* (NU); C, *Robinson 5331* (K); D, extreme base of B showing detail of attachment of glumellae (note prickle hairs). Scale bars, A, B, C = 500 μm; D = 50 μm.

tions are mostly very localized, often small, and in KwaZulu-Natal, frequently limited to a few scattered, solitary plants which grow on steep, rocky slopes, associated with coarse grasses in the zone ecotonal between forest and grassland.

In the limited area of Terry's Cave in the Chimanimani National Park, a slightly more extensive population grows along the banks of small streams and among boulders, where nutrients, particularly phosphates, are in short supply (Wild 1963/1964: 126, 127). Other vegetation is sparse, consisting of restiads and short grasses.

Active regeneration of young plants is nowhere clearly evident, at least in South Africa. The species gives evidence of being relictual and should be considered endangered.

Representative specimens studied

MALAWI

—1635 Mount Mulanje: *Chapman 479* (K); *Hilliard & Burtt 6182* (NU); Litchenya Plateau, *Brass 16673, 16740* (K); *E.A. Robinson 5331* (K); *Chapman & Tawakali 5529* (K); path from Tuchila hut to head Ruo Basin, *Brummit 9668* (K); Chambe Plateau, *Blackmore, Brummit & Banda 393* (K).

ZIMBABWE

—1932 Eastern districts, Vumba Mts, Castle Beacon (–BA), *B.S. Fisher 1643* (NU); J. *Browning 296* (NU).

—1933 Eastern districts, Chimanimani National Park, Terry's Cave area (–CC), *Browning 579* several sheets (NU); *Muller 1257 (K).*

SWAZILAND

—2631 Dalriach: (–AC), *Compton C27527* (PRE); Usutu Forests (–CA), *Compton C25481; C32299*.

SOUTH AFRICA

—2330 Mpumalanga, Wolkberg: New Agatha Forest Research Station (–CC), *Hilliard & Burtt 14315* (NU).

—2430 Mpumalanga, Graskop: near God's Window (–DD), *Hilliard & Burtt 14342* (NU).

—2530 Mpumalanga, Witklip: Above Forest Station (–BB), *Hilliard & Burtt 14279* (NU).

—2731 KwaZulu-Natal, Ngome: (–CD), *Hilliard & Burtt 9927* (NU).

—2830 KwaZulu-Natal, Qudeni: (–DB), *Browning 531* (NU).

—2930 KwaZulu-Natal, Karkloof: Beyond Howick (–AC), *Rycroft 49* (NU); Noodsberg (BD), *Hilliard & Burtt 15468* (NU); Inchanga (–DA), *A.J. Alexander 207* (NU).

—3030 KwaZulu-Natal, Umzinto: Ellesmere B (–AD), *Hilliard & Burtt 14532* (NU).

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